IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Mark Philip D'Evelyn

Serial No.: 09/839,941 : Group Art Unit: 2812

Confirmation No.: 4094

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For: **HOMOEPITAXIAL GALLIUM NITRIDE BASED PHOTODETECTOR AND METHOD OF PRODUCING**

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Commissioner for Patents
P.O. Box 1450
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APPELLANT'S BRIEF

This brief is in furtherance of the Notice of Appeal filed in this case on February 19, 2004.

The required fees and any required petition are dealt with in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief is transmitted in triplicate.

I. Real Party in Interest

The real party in interest is the General Electric Company, a corporation organized under the laws of the state of New York.

II. Related Appeals

There are no related appeals or interferences.

III. Status of Claims

Claims 1-49, 59-106, 124, and 125 remain in the case with none of the claims allowed. Claims 1-123 were presented at the time of filing of the present case. A Restriction Requirement stated that Claims 1-114 are restricted as being directed to separate inventions. The Restriction Requirement stated that Group I is directed to a semiconductor device, classified in Class 257, subclass 184, that includes Claims 1-49 and 59-106 and Group II is directed to a semiconductor substrate, classified in class 257, subclass 103, that includes Claims 50-58 and 107-114. The Restriction Requirement made no statement concerning Claims 115-123 that are method claims.

Claims 50-58 and 107-114 of Group II were withdrawn from consideration by the Examiner as being directed to a non-elected invention. Applicant canceled withdrawn Claims 50-58 and 107-114 of Group II without prejudice or disclaimer to the subject matter therein as being drawn to a non-elected invention. Also, Claims 115-123 were withdrawn from consideration by the Examiner. Applicants reaffirmed cancellation of withdrawn Claims 115-123 without prejudice or disclaimer to the subject matter therein as being drawn to a non-elected invention, in the Amendment facsimiled to the USPTO on September 4, 2003.

Claims 124, and 125 were added during prosecution. Claims 1, 2, 5, 10, 59, 62, and 67 have been amended. Claims 1-49, 59-106, 124, and 125 are on appeal.

IV. Status of Amendments

No amendment to any of Claims 1-49, 59-106, 124, and 125 was submitted after the Final Office Action dated November 19, 2003. Amendments filed on November 1, 2002, March 27, 2003, April 27, 2003, and September 4, 2003 have been entered.

V. Summary of Invention

One embodiment of the disclosed invention provides a photodetector including a substrate, at least one active layer, and at least one conductive contact structure. The substrate comprises a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2}. The at least one active layer is disposed on the substrate. The at least one conductive contact structure is affixed to at least one of the substrate and the at least one active layer.

Another embodiment of the disclosed invention provides a photodetector including a gallium nitride substrate, at least one active layer, and at least one conductive contact structure. The gallium nitride substrate comprises a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2}. The at least one active layer is disposed on the gallium nitride substrate and comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0< x + y \leq 1$, and $0 \leq z + w \leq 1$. The at least one conductive contact structure is affixed to at least one of the gallium nitride substrate and the at least one active layer.

In yet another embodiment, the disclosed invention provides a photodetector including a substrate, at least one active layer, and at least one conductive contact structure. The substrate comprises a homoepitaxially grown

single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2}. The homoepitaxially grown single crystal gallium nitride wafer is cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar. The at least one active layer is disposed on the substrate. The at least one conductive contact structure is affixed to at least one of the substrate and the at least one active layer.

In still another embodiment, the disclosed invention provides a photodetector including a substrate, at least one active layer, and at least one conductive contact structure. The substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2}. The homoepitaxially grown single crystal gallium nitride wafer is cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar. The at least one active layer is disposed on the gallium nitride substrate and comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$. The at least one conductive contact structure is affixed to at least one of said gallium nitride substrate and said at least one active layer.

A. Claim 1 and Its Dependence (Claims 2-49)

Claim 1 recites a photodetector including a substrate, at least one active layer, and at least one conductive contact structure (See, for example, page 3, ¶ 11; page 6, ¶ 26; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4). The substrate comprises a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2} (See, for example, page 9, ¶ 38). The at least one active layer is disposed on the substrate (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figure 2). The at least one conductive contact structure is affixed to the at least one of the substrate and the at least one active layer (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figures 2, 3, & 4).

Claim 2 recites the photodetector of Claim 1, wherein the at least one active layer comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$ (See, for example, page 6, ¶ 26 and page 10, ¶ 41).

Claim 3 recites the photodetector of Claim 1, wherein the at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$ (See, for example, page 6, ¶ 26 and page 10, ¶ 41).

Claim 4 recites the photodetector of Claim 1, wherein the conductive contact structure comprises at least one of a Schottky contact and an ohmic contact (See, for example, page 10, ¶ 41; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4).

Claim 5 recites the photodetector of Claim 4, wherein the contact comprises the Schottky contact comprising at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof (See, for example, pages 10-11, ¶ 42).

Claim 6 recites the photodetector of Claim 5, wherein the Schottky contact comprises nickel and gold (See, for example, page 10, ¶ 41).

Claim 7 recites the photodetector of Claim 6, wherein a portion of the Schottky contact that contacts the at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition (See, for example, page 10, ¶ 41).

Claim 8 recites the photodetector of Claim 7, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition (See, for example, page 10, ¶ 41).

Claim 9 recites the photodetector of Claim 6, wherein the Schottky contact has a thickness of between about 0.001 microns and about 10 microns (See, for example, page 10, ¶ 41).

Claim 10 recites the photodetector of Claim 4, wherein the contact comprises the ohmic contact affixed to one of an n-doped active layer and the substrate, and wherein the ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals (See, for example, page 12, ¶ 48).

Claim 11 recites the photodetector of Claim 10, wherein the ohmic contact comprises titanium and aluminum (See, for example, page 12, ¶ 48).

Claim 12 recites the photodetector of Claim 11, wherein a portion of the ohmic contact that contacts the substrate is a contact layer comprising a titanium-rich titanium-aluminum composition (See, for example, page 12, ¶ 48).

Claim 13 recites the photodetector of Claim 12, wherein the contact layer is contacted with an aluminum-rich titanium-aluminum composition (See, for example, page 12, ¶ 48).

Claim 14 recites the photodetector of Claim 4, wherein the ohmic contact is affixed to a p-doped active layer, and wherein the ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof (See, for example, pages 11-12, ¶ 46).

Claim 15 recites the photodetector of Claim 14, wherein the ohmic contact comprises gold and nickel (See, for example, pages 11-12, ¶ 46).

Claim 16 recites the photodetector of Claim 15, wherein a portion of the ohmic contact that contacts the p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition (See, for example, pages 11-12, ¶ 46).

Claim 17 recites the photodetector of Claim 16, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition (See, for example, pages 11-12, ¶ 46).

Claim 18 recites the photodetector of Claim 4, wherein at least one of the Schottky contact and the ohmic contact is sputtered onto the substrate (See, for example, page 12, ¶ 47).

Claim 19 recites the photodetector of Claim 4, wherein at least one of the Schottky contact and the ohmic contact is deposited onto the substrate by electron beam evaporation (See, for example, page 12, ¶ 47).

Claim 20 recites the photodetector of Claim 1, wherein the at least one active layer includes an insulating layer disposed on a surface of the substrate, the insulating layer having a resistivity of at least 10^5 Ω-cm (See, for example, page 9, ¶ 39).

Claim 21 recites the photodetector of Claim 20, wherein the insulating layer has a thickness of between about 1 nm and about 10 microns (See, for example, page 10, ¶ 41).

Claim 22 recites the photodetector of Claim 20, wherein the insulating layer has a carrier concentration of up to about 10^{18} cm^{-3} (See, for example, page 10, ¶ 41).

Claim 23 recites the photodetector of Claim 1, wherein the at least one active layer comprises an insulating layer disposed on a surface of the substrate, wherein the substrate is one of a n-doped substrate and an insulating substrate, and wherein the conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of the insulating layer (See, for example, page 10, ¶ 41).

Claim 24 recites the photodetector of Claim 23, wherein the plurality of Schottky contacts are interdigitated with respect to each other (See, for example, page 10, ¶ 41 and Figure 2).

Claim 25 recites the photodetector of Claim 23, wherein the insulating layer is undoped (See, for example, page 10, ¶ 41).

Claim 26 recites the photodetector of Claim 23, further including an n-doped layer disposed between the substrate and the insulating layer (See, for example, page 11, ¶ 43 and Figures 2, 3, & 4).

Claim 27 recites the photodetector of Claim 26, wherein the n-doped layer is n-doped gallium nitride (See, for example, page 13, ¶ 52).

Claim 28 recites the photodetector of Claim 1, wherein the substrate is an n-doped substrate, and wherein the at least one active layer comprises an insulating layer and a first p-doped layer (See, for example, page 11, ¶ 44 and Figure 2). The insulating layer is disposed on a surface of the n-doped substrate (See, for example, page 11, ¶ 44 and Figure 2). The a first p-doped layer disposed on a surface of the insulating layer opposite the n-doped substrate (See, for example, page 11, ¶ 44 and Figure 2). The conductive contact structure comprises a first ohmic contact affixed to the first p-doped layer and a second ohmic contact affixed to the n-doped substrate (See, for example, page 11, ¶ 45 and Figure 3).

Claim 29 recites the photodetector of Claim 28, further comprising a second p-doped layer disposed on a surface of the first p-doped layer opposite the insulating layer (See, for example, pages 12-13, ¶ 52 and Figure 3).

Claim 30 recites the photodetector of Claim 29, wherein the second p-doped layer is p-doped gallium nitride (See, for example, pages 12-13, ¶ 52).

Claim 31 recites the photodetector of Claim 28, wherein the insulating layer and the first p-doped layer each have a thickness of between about 1 nm and about 10 microns (See, for example, page 11, ¶ 44).

Claim 32 recites the photodetector of Claim 28, further comprising an n-doped layer disposed between the n-doped substrate and the insulating layer (See, for example, pages 12-13, ¶ 52 and Figure 3).

Claim 33 recites the photodetector of Claim 1, wherein the at least one active layer comprises an insulating layer disposed on a surface of the substrate, and wherein the conductive contact structure comprises at least one Schottky contact affixed to the insulating layer and at least one ohmic contact affixed to one of the substrate and a first n-doped layer (See, for example, page 13, ¶ 51 and Figure 4).

Claim 34 recites the photodetector of Claim 33, wherein the substrate is an n-doped substrate (See, for example, page 13, ¶ 51).

Claim 35 recites the photodetector of Claim 33, wherein the first n-doped layer is disposed between the substrate and the insulating layer (See, for example, pages 13-14, ¶ 52 and Figure 4).

Claim 36 recites the photodetector of Claim 33, wherein the first n-doped layer has a thickness of between about 1 nm and about 10 microns (See, for example, pages 13-14, ¶ 52).

Claim 37 recites the photodetector of Claim 33, further comprising a second n-doped layer disposed between the substrate and the first n-doped layer, the second n-doped layer contacting the at least one ohmic contact (See, for example, pages 13-14, ¶ 52 and Figure 4).

Claim 38 recites the photodetector of Claim 37, wherein the second n-doped layer comprises n-doped gallium nitride (See, for example, pages 13-14, ¶ 52).

Claim 39 recites the photodetector of Claim 37, wherein the second n-doped layer has a thickness of between about 1 nm and about 10 microns (See, for example, pages 13-14, ¶ 52).

Claim 40 recites the photodetector of Claim 1, wherein at least one of the substrate and the at least one active layer further comprises at least one n-dopant (See, for example, pages 14-15, ¶ 57).

Claim 41 recites the photodetector of Claim 40, wherein the at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen (See, for example, pages 14-15, ¶ 57).

Claim 42 recites the photodetector of Claim 40, wherein the at least one n-dopant is epitaxially deposited in at least one of the substrate and the at least one active layer (See, for example, pages 14-15, ¶ 57).

Claim 43 recites the photodetector of Claim 40, wherein the at least one n-dopant is implanted in at least one of the substrate and the at least one active layer (See, for example, pages 14-15, ¶ 57).

Claim 44 recites the photodetector of Claim 1, wherein at least one of the substrate and the active layer further comprises at least one p-dopant (See, for example, page 15, ¶ 58).

Claim 45 recites the photodetector of Claim 44, wherein the at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium (See, for example, page 15, ¶ 58).

Claim 46 recites the photodetector of Claim 44, wherein the at least one p-dopant is epitaxially deposited in at least one of the substrate and the at least one active layer (See, for example, page 15, ¶ 58).

Claim 47 recites the photodetector of Claim 44, wherein the at least one p-dopant is implanted in at least one of the substrate and the at least one active layer (See, for example, page 15, ¶ 58).

Claim 48 recites the photodetector of Claim 1, wherein the photodetector is a flame detector adapted to detect a flame in a combustion chamber (See, for example, page 15, ¶ 59).

Claim 49 recites the photodetector of Claim 1, the photodetector is capable of detecting a predetermined wavelength of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation (See, for example, original Claims 49 and 106).

B. Claim 59 and Its Dependence (Claims 60-106)

Claim 59 recites a photodetector including a gallium nitride substrate, at least one active layer, and at least one conductive contact structure (See, for example, page 3, ¶ 11; page 6, ¶ 26; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4). The gallium nitride substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2} (See, for example, page 9, ¶ 38). The at least one active layer is disposed on the gallium nitride substrate and comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$ (See, for example, page 6, ¶ 26 and page 10, ¶ 41). The at least one conductive contact structure is affixed to at least one of the gallium nitride substrate and the at least one active layer (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figures 2, 3, & 4).

Claim 60 recites the photodetector of Claim 59, wherein the at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$ (See, for example, page 6, ¶ 26 and page 10, ¶ 41).

Claim 61 recites the photodetector of Claim 59, wherein the conductive contact structure comprises at least one of a Schottky contact and an ohmic contact (See, for example, page 10, ¶ 41; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4).

Claim 62 recites the photodetector of Claim 61, wherein the contact comprises the Schottky contact comprising at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof (See, for example, pages 10-11, ¶ 42).

Claim 63 recites the photodetector of Claim 62, wherein the Schottky contact comprises nickel and gold (See, for example, page 10, ¶ 41).

Claim 64 recites the photodetector of Claim 63, wherein a portion of the Schottky contact that contacts the at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition (See, for example, page 10, ¶ 41).

Claim 65 recites the photodetector of Claim 64, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition (See, for example, page 10, ¶ 41).

Claim 66 recites the photodetector of Claim 62, wherein the Schottky contact has a thickness of between about 0.001 microns and about 10 microns (See, for example, page 10, ¶ 41).

Claim 67 recites the photodetector of Claim 61, wherein the contact comprises the ohmic contact affixed to one of an n-doped active layer and the substrate, and wherein the ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals (See, for example, page 12, ¶ 48).

Claim 68 recites the photodetector of Claim 67, wherein the ohmic contact comprises titanium and aluminum (See, for example, page 12, ¶ 48).

Claim 69 recites the photodetector of Claim 68, wherein a portion of the ohmic contact that contacts the substrate is a contact layer comprising a titanium-rich titanium-aluminum composition (See, for example, page 12, ¶ 48).

Claim 70 recites the photodetector of Claim 69, wherein the contact layer is contacted with an aluminum-rich titanium-aluminum composition (See, for example, page 12, ¶ 48).

Claim 71 recites the photodetector of Claim 61, wherein the ohmic contact is affixed to a p-doped active layer, and wherein the ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof (See, for example, pages 11-12, ¶ 46).

Claim 72 recites the photodetector of Claim 71, wherein the ohmic contact comprises gold and nickel (See, for example, pages 11-12, ¶ 46).

Claim 73 recites the photodetector of Claim 72, wherein a portion of the ohmic contact that contacts the p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition (See, for example, pages 11-12, ¶ 46).

Claim 74 recites the photodetector of Claim 73, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition (See, for example, pages 11-12, ¶ 46).

Claim 75 recites the photodetector of Claim 61, wherein at least one of the Schottky contact and the ohmic contact is sputtered onto the substrate (See, for example, page 12, ¶ 47).

Claim 76 recites the photodetector of Claim 61, wherein at least one of the Schottky contact and the ohmic contact is deposited onto the substrate by electron beam evaporation (See, for example, page 12, ¶ 47).

Claim 77 recites the photodetector of Claim 59, wherein the at least one active layer includes an insulating layer disposed on a surface of the substrate, the insulating layer having a resistivity of at least 10^5 Ω-cm (See, for example, page 9, ¶ 39).

Claim 78 recites the photodetector of Claim 77, wherein the insulating layer has a thickness of between about 1 nm and about 10 microns (See, for example, page 10, ¶ 41).

Claim 79 recites the photodetector of Claim 77, wherein the insulating layer has a carrier concentration of up to about 10^{18} cm^{-3} (See, for example, page 10, ¶ 41).

Claim 80 recites the photodetector of Claim 59, wherein the at least one active layer comprises an insulating layer disposed on a surface of the gallium nitride substrate, wherein the gallium nitride substrate is one of an n-doped gallium nitride substrate and an insulating gallium nitride substrate, and wherein the conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of the insulating layer (See, for example, page 10, ¶ 41).

Claim 81 recites the photodetector of Claim 80, wherein the plurality of Schottky contacts are interdigitated with respect to each other (See, for example, page 10, ¶ 41 and Figure 2).

Claim 82 recites the photodetector of Claim 80, wherein the insulating layer is undoped (See, for example, page 10, ¶ 41).

Claim 83 recites the photodetector of Claim 80, further including an n-doped layer disposed between the gallium nitride substrate and the insulating layer (See, for example, page 11, ¶ 43 and Figures 2, 3, & 4).

Claim 84 recites the photodetector of Claim 83, wherein the n-doped layer is n-doped gallium nitride (See, for example, page 13, ¶ 52).

Claim 85 recites the photodetector of Claim 59, wherein the gallium nitride substrate is an n-doped gallium nitride substrate, and wherein the at least one active layer comprises an insulating layer and a first p-doped layer (See, for example, page 11, ¶ 44 and Figure 2). The insulating layer is disposed on a surface of the n-doped gallium nitride substrate (See, for example, page 11, ¶ 44 and Figure 2). The first p-doped layer is disposed on a surface of the insulating layer opposite the n-doped gallium nitride substrate (See, for example, page 11, ¶ 44 and Figure 2). The conductive contact structure comprises at least one ohmic contact affixed to the first p-doped layer and at least one ohmic contact affixed to the n-doped gallium nitride substrate (See, for example, page 11, ¶ 45 and Figure 3).

Claim 86 recites the photodetector of Claim 85, further comprising a second p-doped layer disposed on a surface of the first p-doped layer opposite the insulating layer (See, for example, pages 12-13, ¶ 52 and Figure 3).

Claim 87 recites the photodetector of Claim 86, wherein the second p-doped layer is p-doped gallium nitride (See, for example, pages 12-13, ¶ 52).

Claim 88 recites the photodetector of Claim 85, wherein the insulating layer and the first p-doped layer each have a thickness of between about 1 nm and about 10 microns (See, for example, page 11, ¶ 44).

Claim 89 recites the photodetector of Claim 85, further comprising a first n-doped layer disposed between the n-doped gallium nitride substrate and the insulating layer (See, for example, pages 12-13, ¶ 52 and Figure 3).

Claim 90 recites the photodetector of Claim 59, wherein the at least one active layer comprises an insulating layer disposed on a surface of the gallium nitride substrate, and wherein the conductive contact structure comprises at least one Schottky contact affixed to the insulating layer and at least one ohmic contact affixed to one of the gallium nitride substrate and a first n-doped layer (See, for example, page 13, ¶ 51 and Figure 4).

Claim 91 recites the photodetector of Claim 90, wherein the gallium nitride substrate is an n-doped gallium nitride substrate (See, for example, page 13, ¶ 51).

Claim 92 recites the photodetector of Claim 90, wherein the first n-doped layer is disposed between the gallium nitride substrate and the insulating layer (See, for example, pages 13-14, ¶ 52 and Figure 4).

Claim 93 recites the photodetector of Claim 90, wherein the first n-doped layer has a thickness of between about 1 nm and about 10 microns (See, for example, pages 13-14, ¶ 52).

Claim 94 recites the photodetector of Claim 92, further comprising a second n-doped layer disposed between the gallium nitride substrate and the

insulating layer, the second n-doped layer contacting the at least one ohmic contact (See, for example, pages 13-14, ¶ 52 and Figure 4).

Claim 95 recites the photodetector of Claim 94, wherein the second n-doped layer comprises n-doped gallium nitride (See, for example, pages 13-14, ¶ 52).

Claim 96 recites the photodetector of Claim 94, wherein the second n-doped layer has a thickness of between about 1 nm and about 10 microns (See, for example, pages 13-14, ¶ 52).

Claim 97 recites the photodetector of Claim 59, wherein at least one of the gallium nitride substrate and the at least one active layer further comprises at least one n-dopant (See, for example, pages 14-15, ¶ 57).

Claim 98 recites the photodetector of Claim 97, wherein the at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen (See, for example, pages 14-15, ¶ 57).

Claim 99 recites the photodetector of Claim 97, wherein the at least one n-dopant is epitaxially deposited in at least one of the gallium nitride substrate and the at least one active layer (See, for example, pages 14-15, ¶ 57).

Claim 100 recites the photodetector of Claim 97, wherein the at least one n-dopant is implanted in at least one of the gallium nitride substrate and the at least one active layer (See, for example, pages 14-15, ¶ 57).

Claim 101 recites the photodetector of Claim 59, wherein at least one of the gallium nitride substrate and the active layer further comprises at least one p-dopant (See, for example, page 15, ¶ 58).

Claim 102 recites the photodetector of Claim 101, wherein the at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium (See, for example, page 15, ¶ 58).

Claim 103 recites the photodetector of Claim 101, wherein the at least one p-dopant is epitaxially deposited in at least one of the gallium nitride substrate and the at least one active layer (See, for example, page 15, ¶ 58).

Claim 104 recites the photodetector of Claim 101, wherein the at least one p-dopant is implanted in at least one of the gallium nitride substrate and the at least one active layer (See, for example, page 15, ¶ 58).

Claim 105 recites the photodetector of Claim 59, wherein the photodetector is a flame detector adapted to detect a flame in a combustion chamber (See, for example, page 15, ¶ 59).

Claim 106 recites the photodetector of Claim 59, wherein the photodetector is capable of detecting a predetermined range of wavelengths of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation (See, for example, original Claims 49 and 106).

C. Claim 124

Claim 124 recites a photodetector including a substrate, at least one active layer, and at least one conductive contact structure (See, for example, page 3, ¶ 11; page 6, ¶ 26; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4). The substrate comprises a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2} (See, for example, page 9, ¶ 38). The homoepitaxially grown single crystal gallium nitride wafer is cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar (See, for example, pages 6-9, ¶¶ 27-37). The at least one active layer is disposed on the substrate (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figure 2). The at least one conductive contact structure is affixed to at least one of the substrate and the at least one active layer (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figures 2, 3, & 4).

D. Claim 125

Claim 125 recites provides a photodetector including a substrate, at least one active layer, and at least one conductive contact structure (See, for example, page 3, ¶ 11; page 6, ¶ 26; page 11, ¶ 44; page 13, ¶ 51; and Figures 2, 3, & 4). The substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2} (See, for example, page 9, ¶ 38) The homoepitaxially grown single crystal gallium nitride wafer is cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar (See, for example, pages 6-9, ¶¶ 27-37). The at least one active layer is disposed on the gallium nitride substrate and comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0< x + y \leq 1$, and $0 \leq z + w \leq 1$ (See, for example, page 6, ¶ 26 and page 10, ¶ 41). The at least one conductive contact structure is affixed to at least one of the gallium nitride substrate and the at least one active layer (See, for example, page 3, ¶ 11; page 6, ¶ 26; and Figures 2, 3, & 4).

VI. Issues

A. Whether Claims 1-5, 14, 18-19, 33, 36, 59-62, 71, 75-76, 124, and 125 are patentable under 35 U.S.C. § 103(a) over Chen (US 6,104,074) in view of Tischler et al. (US 5,679,152) and Tadatomo et al. (US 6,225,650).

B. Whether Claims 6-9, 15-17, 20-22, 63-66, 72-74, 77-79, and 107 are patentable under 35 U.S.C. § 103(a) over Chen (US 6,104,074) in view of Soares (US 6,034,404).

C. Whether Claims 10-13 and 67-70 are patentable under 35 U.S.C. § 103(a) over Chen (US 6,104,074) in view of McTeer (US 6,258,466).

D. Whether Claims 23-32, 34-35, 37-44, 80-92, and 94-101 are patentable under 35 U.S.C. § 103(a) over Chen (US 6,104,074) in view of Mueller (US 4,902,136) and Gerner et al. (US 5,698,865).

E. Whether Claims 45-49 and 102-106 are patentable under 35 U.S.C. § 103(a) over Chen (US 6,104,074) in view of Saito et al. (US 6,121,634).

VII. Grouping of Claims

Each claim is separately patentable as defining the invention differently.

VIII. Arguments

The Examiner rejected Claims 1-5, 14, 18-19, 33, 36, 59-62, 71, 75-76, 124, and 125 under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of Tischler et al. (US 5,679,152) and Tadatomo et al. (US 6,225,650). The Examiner asserted that Claims 1-5, 14, 18-19, 33, 36, 59-62, 71, 75-76, 124, and 125 were obvious and therefore unpatentable over Chen in view of Tischler et al. and Tadatomo et al.

The Examiner rejected Claims 6-9, 15-17, 20-22, 63-66, 72-74, 77-79, and 107 under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of Soares (US 6,034,404). The Examiner asserted that Claims 6-9, 15-17, 20-22, 63-66, 72-74, 77-79, and 107 were obvious and therefore unpatentable over Chen in view of Soares.

The Examiner rejected Claims 10-13 and 67-70 under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of McTeer (US 6,258,466). The Examiner asserted that Claims 10-13 and 67-70 were obvious and therefore unpatentable over Chen in view of McTeer.

The Examiner rejected Claims 23-32, 34-35, 37-44, 80-92, and 94-101 under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of Mueller (US 4,902,136) and Gerner et al. (US 5,698,865). The Examiner asserted that Claims 23-32, 34-35, 37-44, 80-92, and 94-101 were obvious and therefore unpatentable over Chen in view of Mueller and Gerner et al.

The Examiner rejected Claims 45-49 and 102-106 under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of Saito et al. (US 6,121,634). The Examiner asserted that Claims 45-49 and 102-106 were obvious and therefore unpatentable over Chen in view of Saito et al.

A. Chen teaches basal plane sapphire substrates.

Chen discloses basal plane sapphire substrates (See, for example, Col. 2, lines 27-28 and lines 35-37; Col. 3, lines 28-30; and Col. 4, lines 22-28, Col. 5, lines 48-49 and Col.. 7, lines 39-61) not a single crystal gallium nitride substrate let alone as homoepitaxially grown single crystal gallium nitride.

B. Tischler et al. teaches a heteroepitaxially grown single crystal Ga*N article

Tischler et al. teaches that a heteroepitaxially grown single crystal Ga*N article grown on a material such as silicon, silicon carbide, gallium arsenide, sapphire (See, for example, Col. 2, lines 42-44 and Col. 7, lines 21-23) by suitable techniques, such as vapor deposition techniques, including chemical vapor deposition (CVD), chemical vapor transport (CVT), physical vapor deposition (PVD), plasma-assisted CVD, etc. (See, for example, Col. 7, lines 17-21). In a specific embodiment, Tischler et al. teaches heteroepitaxially growing GaN on silicon in a temperature range of 800°-1300°C using a vapor phase process (See, for example, Col. 5, lines 49-52).

C. Tadatomo et al. teaches heteroepitaxially growing a GaN group crystal layer

Tadatomo et al. teaches heteroepitaxially growing a GaN group crystal layer on a base substrate that may be sapphire crystal (C face, A face), rock crystal, SiC and the like which are widely used to form GaN group crystal layers by any method (See, for example, Col. 4, lines 12-16 and Examples) such as the hydride vapor phase epitaxy (HVPE) method, the Metalorganic Chemical Vapor Deposition (MOCVD) method, the Molecular Beam Epitaxy (MBE) method and the like (See, for example, Col. 5, lines 10-12)

D. Chen in view of Tischler et al. and Tadatomo et al. does not meet the claimed inventions.

The Examiner stated that Chen failed to disclose a substrate having a dislocation density of less than about 10^3 cm^{-2}. Then, the Examiner stated that Tadatomo et al. did disclose the dislocation density of a GaN layer grown by the HVPE process is not more than 10^3 cm^{-2}. This combination Chen and Tadatomo et al. fails to meet the claimed inventions including a combination of a homoepitaxially grown single crystal gallium nitride wafer and other recited features.

Also, the Examiner stated that Chen failed to disclose $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, $0 < x + y \leq 1$. Then, the Examiner stated that did disclose epitaxially growing a binary (GaN) or quaternary (AlInGaN). Again, this combination of Chen and Tischler et al. fails to meet the claimed inventions including a combination of a homoepitaxially grown single crystal gallium nitride wafer and other recited features.

Incorrectly, the Examiner insists that these aspects of the cited references to arrive at the conclusion that Claims 1-5, 14, 18-19, 33, 36, 59-62, 71, 75-76, 124, and 125 would have been obvious under 35 U.S.C. 103(a).

In the Office Action, mailed on November 19, 2003, the Examiner states at page 10 in the section entitled "Response to Arguments":

> Applicant submits that neither Chen no [sic] Tischler et al. nor Tadatomo et al. teaches or suggests homoepitaxially grown a single crystal gallium nitride substrate (page 22). However, Tischler et al. teach heteroepitaxially growing an n-GaN layer 30 on a silicon handling substrate and epitaxially grown an GaN substrate 26 over the n-GaN layer 30 (fig. 2-6). An GaN substrate epitaxially grown on an immediate n-GaN layer is homoepitaxially grown. This meets the claimed limitation.

Applicant respectfully disagrees. Among other things, Tischler et al. characterizes the growth of the Ga*N as heteroepitaxial when discussing the use of so-called buffer layers to improve crystal quality, for example, at Col. 9, lines 4-8 reproduced below.

> ... This so-called buffer layer is commonly used in <u>heteroepitaxial growth</u> to improve crystal quality. For example, in this case it may comprise a grown layer of silicon on the sacrificial silicon substrate, to improve the surface of the substrate before deposition of the Ga*N. ...

Emphasis Added

Furthermore, Tischler et al. teaches at Col. 9, lines 32-35, that the silicon-doped GaN layer 82 shown in Figure 8 is "formed by diffusion of silicon out of a sacrificial silicon substrate during the growth of the single crystal GaN article, as described above." At Col. 6, lines 29-48, Tischler et al. states:

> It is possible that the constituents of the sacrificial substrate may act as a dopant for the desired substrate layer, either by a solid state diffusion process through the interface between the sacrificial substrate and into the Ga*N layer or by "auto-doping," wherein the some [sic] amount of the sacrificial substrate material enters the vapor phase at the growth temperature and dopes the Ga*N layer as it is growing. If this latter situation is the case, the back side of the sacrificial substrate could be covered with a suitable mask such as silicon dioxide or silicon nitride to prevent autodoping of the grown layer. However, there may be some diffusion of the sacrificial substrate material into the desired grown layer at the interface. This could be beneficial, as for example in the case of a sacrificial silicon substrate and a grown GaN layer, in which the silicon would form a heavily doped n-type layer at the back of the substrate. Such heavily doped n-type layer would be

> advantageous for forming n-type ohmic contacts. If this layer were not desired, it could be etched or polished off after the growth process had been completed.

The teachings of the above-cited paragraphs would therefore lead one skilled in the art to conclude that the single crystal Ga*N 26 is heteroepitaxially grown, and that a diffusion of silicon from the silicon substrate 20 into the heteroepitaxial Ga*N 26 creates the layer 30 of silicon-doped n-type Ga*N depicted in Figures 5 and 6. Thus, layer 30 of silicon-doped n-type Ga*N and single crystal Ga*N 26 are heteroepitaxially grown.

Applicant therefore submits that, because the combination of references cited by the Examiner fails to teach or suggest all of the limitations of independent Claims 1, 59, 124, and 125, the rejection of these independent claims and the 2-5, 14, 18-19, 33, 36, 60-62, 71, and 75-76 dependent thereon under 35 U.S.C. §103(a) as being unpatentable over Chen in view of Tischler et al. and Tadatomo et al. is improper and should be withdrawn.

F. Soares.

The Examiner states that Claims 6-9, 15-17, 20-22, 63-66, 72-74, 77-79, and 107 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Chen in view of Soares (US 6,034,404). As noted above, Chen discloses basal plane sapphire substrates, not a single crystal gallium nitride substrate. As the shortcomings of Chen are not cured by Soares, the 35 U.S.C. § 103(a) rejection of Claims 6-9, 15-17, 20-22, 63-66, 72-74, 77-79, and 107 is improper and should be withdrawn.

G. McTeer.

The Examiner states that Claims 10-13 and 67-70 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Chen in view of McTeer. As with Chen in view of Soares, the shortcomings of Chen are not cured by McTeer. As the shortcomings of Chen are not cured by McTeer, the 35 U.S.C. § 103(a) rejection of Claims 10-13 and 67-70 is improper and should be withdrawn.

H. Gerner et al.

The Examiner states that Claims 23-32, 34-35, 37-44, 80-92, and 94-101 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Chen in view of Mueller (US 4,902,136) and Gerner et al. As with Chen in view of Soares, the shortcomings of Chen are not cured by Mueller and Gerner et al. As the shortcomings of Chen are not cured by Mueller and Gerner et al., the 35 U.S.C. § 103(a) rejection of Claims 23-32, 34-35, 37-44, 80-92, and 94-101 is improper and should be withdrawn.

I. Saito et al.

The Examiner states that Claims 45-49 and 102-106 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Chen (US 6,104,074) in view of Saito et al. (US 6,121,634). As with Chen in view of Soares, the shortcomings of Chen are not cured by Saito et al. As the shortcomings of Chen are not cured by Saito et al., the 35 U.S.C. § 103(a) rejection of Claims 45-49 and 102-106 is improper and should be withdrawn.

J. The Office Action does not meet Federal Circuit requirements.

The claimed invention is not taught or suggested by any of the cited references. A rejection of a claim in a utility application under 35 U.S.C. § 103(a) based on combinations of prior art references is a legal conclusion, which must be based on underlying factual inquiries including: (1) the scope and content of the prior art; (2) the level of ordinary skill in the prior art; (3) the differences between the claimed invention and the prior art; and (4) objective evidence of obviousness. First, the references must provide the respective elements to yield the claimed invention. Then, the references must provide one of ordinary skill a motivation to combine their respective elements to yield the claimed invention. *In Re Dembiczak*, 50 U.S.P.Q. 2d 1614 (Fed. Cir. 1999). The references fail to provide the respective elements to yield the claimed invention. Thus, the references can not provide any motivation to combine their respective elements to yield the claimed invention.

In the case of *In re Lee*, 61 U.S.P.Q. 2d (Fed. Cir. 2002), the court indicated that the findings under 35 U.S.C. § 103 must be based on reasoned findings that one of ordinary skill in the art would have been motivated to select and combine the references. The Court further indicated that the findings and the grounds thereof must be clearly indicated on the record. A careful review of the Office Action does not reveal any reasoned findings in support of the conclusions of obviousness. The Office Action merely contains the unsupported conclusion that the references are combinable and that the combination renders the applicant's inventions unpatentable. The evidence of motivation and reasoned analysis required by *In re Dembiczak* and *In re Lee* is missing. Moreover, as the combination of Chen in view of any of the art of record, whether taken alone or in combination, fails to teach or suggest the claimed inventions, the Examiner has failed to meet the burden of providing a reasoned decision to support the any rejection on factual grounds. Because the reasoned analysis with supporting factual grounds can not be made, it would appear that hindsight

was the only basis for the combination of references. Hindsight is an improper tool in obviousness evaluations.

K. Conclusion

The Examiner's rejections of Claims 1-49, 59-106, 124, and 125 should be reversed.

IX. Appendix of Claims

The appealed claims are as follows:

1. (Currently Amended) A photodetector, the photodetector comprising:

a) a substrate, the substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2};

b) at least one active layer disposed on the substrate; and

c) at least one conductive contact structure affixed to at least one of the substrate and the at least one active layer.

2. (Currently Amended) The photodetector of claim 1, wherein the at least one active layer comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$.

3. (Original) The photodetector of claim 2, wherein the at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$.

4. (Original) The photodetector of claim 1, wherein the conductive contact structure comprises at least one of a Schottky contact and an ohmic contact.

5. (Currently Amended) The photodetector of claim 4, wherein the contact comprises the Schottky contact comprising at least one of a metal and a metal

oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

6. (Original) The photodetector of claim 5, wherein the Schottky contact comprises nickel and gold.

7. (Original) The photodetector of claim 6, wherein a portion of the Schottky contact that contacts the at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

8. (Original) The photodetector of claim 7, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

9. (Original) The photodetector of claim 6, wherein the Schottky contact has a thickness of between about 0.001 microns and about 10 microns.

10. (Currently Amended) The photodetector of claim 4, wherein the contact comprises the ohmic contact affixed to one of an n-doped active layer and the substrate, and wherein the ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals.

11. (Original) The photodetector of claim 10, wherein the ohmic contact comprises titanium and aluminum.

12. (Original) The photodetector of claim 11, wherein a portion of the ohmic contact that contacts the substrate is a contact layer comprising a titanium-rich titanium-aluminum composition.

13. (Original) The photodetector of claim 12, wherein the contact layer is contacted with an aluminum-rich titanium-aluminum composition.

14. (Original) The photodetector of claim 4, wherein the ohmic contact is affixed to a p-doped active layer, and wherein the ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

15. (Original) The photodetector of claim 14, wherein the ohmic contact comprises gold and nickel.

16. (Original) The photodetector of claim 15, wherein a portion of the ohmic contact that contacts the p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

17. (Original) The photodetector of claim 16, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

18. (Original) The photodetector of claim 4, wherein at least one of the Schottky contact and the ohmic contact is sputtered onto the substrate.

19. (Original) The photodetector of claim 4, wherein at least one of the Schottky contact and the ohmic contact is deposited onto the substrate by electron beam evaporation.

20. (Original) The photodetector of claim 1, wherein the at least one active layer includes an insulating layer disposed on a surface of the substrate, the insulating layer having a resistivity of at least 10^5 Ω-cm.

21. (Original) The photodetector of claim 20, wherein the insulating layer has a thickness of between about 1 nm and about 10 microns.

22. (Original) The photodetector of claim 20, wherein the insulating layer has a carrier concentration of up to about 10^{18} cm^{-3}.

23. (Original) The photodetector of claim 1, wherein the at least one active layer comprises an insulating layer disposed on a surface of the substrate, wherein the substrate is one of a n-doped substrate and an insulating substrate,

and wherein the conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of the insulating layer.

24. (Original) The photodetector of claim 23, wherein the plurality of Schottky contacts are interdigitated with respect to each other.

25. (Original) The photodetector of claim 23, wherein the insulating layer is undoped.

26. (Original) The photodetector of claim 23, further including an n-doped layer disposed between the substrate and the insulating layer.

27. (Original) The photodetector of claim 26, wherein the n-doped layer is n-doped gallium nitride.

28. (Original) The photodetector of claim 1, wherein the substrate is an n-doped substrate, and wherein the at least one active layer comprises:

a) an insulating layer disposed on a surface of the n-doped substrate; and

b) a first p-doped layer disposed on a surface of the insulating layer opposite the n-doped substrate,

wherein the conductive contact structure comprises a first ohmic contact affixed to the first p-doped layer and a second ohmic contact affixed to the n-doped substrate.

29. (Original) The photodetector of claim 28, further comprising a second p-doped layer disposed on a surface of the first p-doped layer opposite the insulating layer.

30. (Original) The photodetector of claim 29, wherein the second p-doped layer is p-doped gallium nitride.

31. (Original) The photodetector of claim 28, wherein the insulating layer and the first p-doped layer each have a thickness of between about 1 nm and about 10 microns.

32. (Original) The photodetector of claim 28, further comprising an n-doped layer disposed between the n-doped substrate and the insulating layer.

33. (Original) The photodetector of claim 1, wherein the at least one active layer comprises an insulating layer disposed on a surface of the substrate, and wherein the conductive contact structure comprises at least one Schottky contact affixed to the insulating layer and at least one ohmic contact affixed to one of the substrate and a first n-doped layer.

34. (Original) The photodetector of claim 33, wherein the substrate is an n-doped substrate.

35. (Original) The photodetector of claim 33, wherein the first n-doped layer is disposed between the substrate and the insulating layer.

36. (Original) The photodetector of claim 33, wherein the first n-doped layer has a thickness of between about 1 nm and about 10 microns.

37. (Original) The photodetector of claim 33, further comprising a second n-doped layer disposed between the substrate and the first n-doped layer, the second n-doped layer contacting the at least one ohmic contact.

38. (Original) The photodetector of claim 37, wherein the second n-doped layer comprises n-doped gallium nitride.

39. (Original) The photodetector of claim 37, wherein the second n-doped layer has a thickness of between about 1 nm and about 10 microns.

40. (Original) The photodetector of claim 1, wherein at least one of the substrate and the at least one active layer further comprises at least one n-dopant.

41. (Original) The photodetector of claim 40, wherein the at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen.

42. (Original) The photodetector of claim 40, wherein the at least one n-dopant is epitaxially deposited in at least one of the substrate and the at least one active layer.

43. (Original) The photodetector of claim 40, wherein the at least one n-dopant is implanted in at least one of the substrate and the at least one active layer.

44. (Original) The photodetector of claim 1, wherein at least one of the substrate and the active layer further comprises at least one p-dopant.

45. (Original) The photodetector of claim 44, wherein the at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium.

46. (Original) The photodetector of claim 44, wherein the at least one p-dopant is epitaxially deposited in at least one of the substrate and the at least one active layer.

47. (Original) The photodetector of claim 44, wherein the at least one p-dopant is implanted in at least one of the substrate and the at least one active layer.

48. (Original) The photodetector of claim 1, wherein the photodetector is a flame detector adapted to detect a flame in a combustion chamber.

49. (Original) The photodetector of claim 1, wherein, the photodetector is capable of detecting a predetermined wavelength of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation.

Claims 50-58 (canceled).

59. (Currently Amended) A photodetector, the photodetector comprising:

a) a gallium nitride substrate, the gallium nitride substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2}, wherein the gallium nitride wafer is grown by precipitating gallium nitride onto one of at least one gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed;

b) at least one active layer disposed on the gallium nitride substrate, the at least one active layer comprising $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$; and

c) at least one conductive contact structure affixed to at least one of the gallium nitride substrate and the at least one active layer.

60. (Original) The photodetector of claim 59, wherein the at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$.

61. (Original) The photodetector of claim 59, wherein the conductive contact structure comprises at least one of a Schottky contact and an ohmic contact.

62. (Currently Amended) The photodetector of claim 61, wherein the contact comprises the Schottky contact comprising at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

63. (Original) The photodetector of claim 62, wherein the Schottky contact comprises nickel and gold.

64. (Original) The photodetector of claim 63, wherein a portion of the Schottky contact that contacts the at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

65. (Original) The photodetector of claim 64, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

66. (Original) The photodetector of claim 62, wherein the Schottky contact has a thickness of between about 0.001 microns and about 10 microns.

67. (Currently Amended) The photodetector of claim 61, wherein the contact comprises the ohmic contact affixed to one of an n-doped active layer and the substrate, and wherein the ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals.

68. (Original) The photodetector of claim 67, wherein the ohmic contact comprises titanium and aluminum.

69. (Original) The photodetector of claim 68, wherein a portion of the ohmic contact that contacts the substrate is a contact layer comprising a titanium-rich titanium-aluminum composition.

70. (Original) The photodetector of claim 69, wherein the contact layer is contacted with an aluminum-rich titanium-aluminum composition.

71. (Original) The photodetector of claim 61, wherein the ohmic contact is affixed to a p-doped active layer, and wherein the ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

72. (Original) The photodetector of claim 71, wherein the ohmic contact comprises gold and nickel.

73. (Original) The photodetector of claim 72, wherein a portion of the ohmic contact that contacts the p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

74. (Original) The photodetector of claim 73, wherein the contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

75. (Original) The photodetector of claim 61, wherein at least one of the Schottky contact and the ohmic contact is sputtered onto the substrate.

76. (Original) The photodetector of claim 61, wherein at least one of the Schottky contact and the ohmic contact is deposited onto the substrate by electron beam evaporation.

77. (Original) The photodetector of claim 59, wherein the at least one active layer includes an insulating layer disposed on a surface of the substrate, the insulating layer having a resistivity of at least 10^5 Ω-cm.

78. (Original) The photodetector of claim 77, wherein the insulating layer has a thickness of between about 1 nm and about 10 microns.

79. (Original) The photodetector of claim 77, wherein the insulating layer has a carrier concentration of up to about 10^{18} cm^{-3}.

80. (Original) The photodetector of claim 59, wherein the at least one active layer comprises an insulating layer disposed on a surface of the gallium nitride substrate, wherein the gallium nitride substrate is one of an n-doped gallium nitride substrate and an insulating gallium nitride substrate, and wherein the conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of the insulating layer.

81. (Original) The photodetector of claim 80, wherein the plurality of Schottky contacts are interdigitated with respect to each other.

82. (Original) The photodetector of claim 80, wherein the insulating layer is undoped.

83. (Original) The photodetector of claim 80, further including an n-doped layer disposed between the gallium nitride substrate and the insulating layer.

84. (Original) The photodetector of claim 83, wherein the n-doped layer is n-doped gallium nitride.

85. (Original) The photodetector of claim 59, wherein the gallium nitride substrate is an n-doped gallium nitride substrate, and wherein the at least one active layer comprises:

a) an insulating layer disposed on a surface of the n-doped gallium nitride substrate; and

b) a first p-doped layer disposed on a surface of the insulating layer opposite the n-doped gallium nitride substrate,

wherein the conductive contact structure comprises at least one ohmic contact affixed to the first p-doped layer and at least one ohmic contact affixed to the n-doped gallium nitride substrate.

86. (Original) The photodetector of claim 85, further comprising a second p-doped layer disposed on a surface of the first p-doped layer opposite the insulating layer.

87. (Original) The photodetector of claim 86, wherein the second p-doped layer is p-doped gallium nitride.

88. (Original) The photodetector of claim 85, wherein the insulating layer and the first p-doped layer each have a thickness of between about 1 nm and about 10 microns.

89. (Original) The photodetector of claim 85, further comprising a first n-doped layer disposed between the n-doped gallium nitride substrate and the insulating layer.

90. (Original) The photodetector of claim 59, wherein the at least one active layer comprises an insulating layer disposed on a surface of the gallium nitride substrate, and wherein the conductive contact structure comprises at least one Schottky contact affixed to the insulating layer and at least one ohmic contact affixed to one of the gallium nitride substrate and a first n-doped layer.

91. (Original) The photodetector of claim 90, wherein the gallium nitride substrate is an n-doped gallium nitride substrate.

92. (Original) The photodetector of claim 90, wherein the first n-doped layer is disposed between the gallium nitride substrate and the insulating layer.

93. (Original) The photodetector of claim 92, wherein the first n-doped layer has a thickness of between about 1 nm and about 10 microns.

94. (Original) The photodetector of claim 92, further comprising a second n-doped layer disposed between the gallium nitride substrate and the insulating layer, the second n-doped layer contacting the at least one ohmic contact.

95. (Original) The photodetector of claim 94, wherein the second n-doped layer comprises n-doped gallium nitride.

96. (Original) The photodetector of claim 94, wherein the second n-doped layer has a thickness of between about 1 nm and about 10 microns.

97. (Original) The photodetector of claim 59, wherein at least one of the gallium nitride substrate and the at least one active layer further comprises at least one n-dopant.

98. (Original) The photodetector of claim 97, wherein the at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen.

99. (Original) The photodetector of claim 97, wherein the at least one n-dopant is epitaxially deposited in at least one of the gallium nitride substrate and the at least one active layer.

100. (Original) The photodetector of claim 97, wherein the at least one n-dopant is implanted in at least one of the gallium nitride substrate and the at least one active layer.

101. (Original) The photodetector of claim 59, wherein at least one of the gallium nitride substrate and the active layer further comprises at least one p-dopant.

102. (Original) The photodetector of claim 101, wherein the at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium.

103. (Original) The photodetector of claim 101, wherein the at least one p-dopant is epitaxially deposited in at least one of the gallium nitride substrate and the at least one active layer.

104. (Original) The photodetector of claim 101, wherein the at least one p-dopant is implanted in at least one of the gallium nitride substrate and the at least one active layer.

105. (Original) The photodetector of claim 59, wherein the photodetector is a flame detector adapted to detect a flame in a combustion chamber.

106. (Original) The photodetector of claim 59, wherein the photodetector is capable of detecting a predetermined range of wavelengths of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation.

Claims 107-123 (canceled).

124. (NEW) A photodetector, the photodetector, comprising:

a) a substrate, the substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^3 cm^{-2} cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar;

b) at least one active layer disposed on the substrate; and

c) at least one conductive contact structure affixed to at least one of the substrate and the at least one active layer.

125. (NEW) A photodetector, the photodetector comprising:

a) a substrate, the substrate comprising a homoepitaxially grown single crystal gallium nitride wafer having a dislocation density of less than about 10^5 cm^{-2} cut from a portion of a boule grown by precipitating gallium nitride onto at least one of a gallium nitride crystal, a gallium nitride boule, and a gallium nitride crystal seed using a supercritical solvent at a temperature greater than about 550°C and a pressure greater than about 5 kbar;

b) at least one active layer disposed on the gallium nitride substrate, the at least one active layer comprising $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$ and at least one of x and y have a non-zero value, wherein $0 < x + y \leq 1$, and $0 \leq z + w \leq 1$; and

c) at least one conductive contact structure affixed to at least one of the gallium nitride substrate and the at least one active layer.

Respectfully submitted,

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Date: April 19, 2004

File No.: RD-27,966-2 (05005470.003US1)

CERTIFICATE OF MAILING

I HEREBY CERTIFY THAT THIS DOCUMENT IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE AS FIRST-CLASS MAIL, IN AN ENVELOPE ADDRESSED TO: MAIL STOP APPEAL BRIEF-PATENTS, COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450, ON: April 19, 2004
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Serial No. 09/839,941 RD-27,966-2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Mark Philip D'Evelyn

Serial No.: 09/839,941 : Group Art Unit: 2812

Confirmation No.: 4094 : Examiner: Wai Sing Louie

Filed: April 20, 2001

For: **HOMOEPITAXIAL GALLIUM NITRIDE BASED PHOTODETECTOR AND METHOD OF PRODUCING**

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF APPEAL BRIEF

Transmitted herewith in triplicate is the Appeal Brief in this application with respect to the Notice of Appeal filed on February 19, 2004.

A check in the amount of $330.00 is enclosed to cover the required fee for filing the Appeal Brief, pursuant to 37 C.F.R. 1.17(c).

If any Extension of Time or additional fees for the accompanying response are required, Applicant requests that this be considered a Petition therefor. The Commissioner is hereby authorized to charge any additional fees that may be required to Deposit Account 502190.

Respectfully submitted,

Robert P. Santandrea
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